ABS ACTA BIOLOGICA SIBIRICA
A journal on the biodiversity of Siberia and the adjacent lands

Acta Biologica Sibirica 7: 545–558 (2021)
doi: 10.3897/abs.7.e78477
https://abs.pensoft.net

RESEARCH ARTICLE

Synanthropization and species diversity of floodplain ecosystems of the Ob-Irtysh basin, Russia

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Academic editor: A. Matsyura | Received 25 December 2021 | Accepted 3 December 2021 | Published 22 December 2021

http://zoobank.org/737E238A-7022-4CB0-BEDF-9E6D972109EA

Citation: Popova EI (2021) Synanthropization and species diversity of floodplain ecosystems of the Ob-Irtysh basin, Russia. Acta Biologica Sibirica 7: 545–558. https://doi.org/10.3897/abs.7.e78477

Abstract

Currently, the phytocenoses of the Irtysh floodplain are experiencing intense anthropogenic pressures due to the intensive development of the oil and gas industry, as well as the urbanization of the territory. This paper focuses on the structure and species composition of the 27 studied areas in the floodplain ecosystems of the Ob-Irtysh basin. As a result of the research, we found 111 species of vascular plants from 33 families in plant communities. The areas belong to meadows and forest vegetation are represented by (1) birch forests (33%), (2) pine forests (10%), (3) fir forests (8%), (4) aspen forests (4%) and (5) associations of meadows (45%). Furthermore, we conducted a comparative analysis of the studied phytocenoses according to the Drude scale. To determine the anthropogenic transformation of the flora and individual plant communities, we determined the synanthropization index (the ratio of synanthropic species to the total number of species). In the synanthropic flora fraction, we distinguished 45 species belonging to 12 families, with the most multispecies being Apiaceae, Scrophulariaceae, Compositeae, Ranunculaceae, Poaceae, Fabaceae, Plantaginaceae. The synanthropization index of the studied phytocenoses ranges from 6.6% to 81.2%. The largest number of synanthropic species occurs in meadow associations, the content of synanthropes is greater than 50%, the structure is becoming more superficial, and the productivity and stability of plant communities are changing. The study of the horizontal structure of grass stands of meadow phytocenoses makes it possible to find the variability of different years, the change of dominant species and the stability of the species composition. Currently, researchers are paying considerable attention to the analysis of the structure of the herbage, since its study is of great theoretical and practical importance in clarifying phytocenotic relations.

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Keywords
Floodplain sites, synanthropic species, synanthropization index, plant communities, species diversity

Introduction

The Irtysh River originates from China and flows through Kazakhstan with its industrial enterprises that discharge heavy metal waste water into the Irtysh River. The excessive human impact on the flora causes a number of adverse effects by disrupting the ecological balance and undermining the resource potential of the floodplain area. As a result, floodplain ecosystems have begun to degrade: the biological productivity of the floodplain, including the yield of meadow grasses, has declined. Plant communities in the Irtysh floodplain are under high anthropogenic loads arising from the fast development of the oil and gas industry, as well as from the urbanization of the region. At present, the anthropogenic impact on the environment is steadily growing, leading to the transformation of the vegetation cover, synanthropization, and the subsequent destruction of natural vegetation. As the main components of the green cover, the plant communities are of primary importance. We pay particular attention to understanding the mechanisms of transformation and sustainability of communities (Menning and Feder 1985; Polozghiy et al. 1996; Thapa et al. 2016; Seer et al. 2018; Ochs et al. 2019).

A necessary condition for the normal functioning of ecosystems and the biosphere is a sufficient level of species diversity. Vegetation cover, being the main environmental stabilizing factor in the functioning of geosystems, plays the critical role in maintaining their structure and regulating dynamics (Cherepanov 1981; Kumar et al. 2006; Konsoer et al. 2017; Croissant et al. 2019; Gregory et al. 2019).

The study of patterns in the transformation of plant communities into synanthropic or almost synanthropic communities is becoming an urgent problem. As the most common variation of anthropoflorogenesis, the synanthropization of the vegetation cover of cities, individual regions, and various types of natural habitats is the research object.

Material and methods

To determine the abundance, we used the Drude scale (a system of point-based ocular estimate grades used for assessment of the abundance of the species): soc (socialis) – plants close in on the above-ground part, completely; cop^3 (from copiosa – copious) – very copious; cop^2 – copious; cop^1 – fairly copious; sp (sparsae) – absentmindedly; sol (solitaries) – thin, scattered; un (unicum) – occurs singly (Kharitintsev 1994; Naumenko 2004; Kulikov 2010).

To identify the transformation of flora and individual plant communities, we evaluated the synanthropization index (the ratio of synanthropic species to the total number of species) (Pellissier et al. 2013).

We assessed the degree of synanthropization using the R method. I. Burda (1991). The percentage is calculated using formula (1):

$$X=S_{sp}/S_t \times 100\% , \quad (1)$$

where S_{sp} – the number of synanthropic species; S_t – the total number of species on the site.

Assessment of the degree of synanthropization according to the five-point system of R. I. Burda (1991):

- one point: the content of synanthropic species at the site is no more than 1%, that is, they are sparsely interspersed in the general background of vegetation;
- two points: the content of synanthropic species on the site is no more than 10%. Found among several plants that form a mass admixture to the background;
- three points: the synanthrope content on the site is not more than 30%. Here they are found among many species, making up a significant part of the general background;
- four points: the content of synanthropes on the site is no more than 50%; that is, their dominance is evident. Synanthropes make up the bulk of the vegetation;
- five points: the content of synanthropes on the site is more than 50%. Synanthropic species occupy most of the site; that is, they dominate, forming a general background in which all other types of vegetation are interspersed.

Results and discussion

The phytocenological study is based on the identification of the floristic composition (a list of species that form a phytocenosis). The basis for floristic analysis in these studies was the list of species of 27 geobotanical descriptions (listed below), which were compiled in areas of floodplain ecosystems of the Ob-Irtysh basin with natural vegetation.

Plot 1. Birch forests of the goutweed-sedge type. Geographical coordinates: 58.491833°, E 68.68065°. On the site, we observed four species: (1) *Betula pendula* Roth, (2) *Pinus sylvestris* L., (3) *Populus tremula* L., and (4) *Tilia cordata* Mill (undergrowth). The grass cover is represented by the following:

- Stratum 1: *Angelica sylvestris* L.;
- Stratum 2: *Centaurea scabiosa* L., *Bromopsis inermis* (Leyss.) Holub, *Geranium sylvaticum* L., *Lathyrus vernus* (L.) Bernh;

- Stratum 3: *Trifolium medium* L., *Rubus saxatilis* L., *Vicia sylvatica* L., *Galium mollugo* L. dominated by *Aegopodium podagraria* L. (cop[1]), *Carex macroura* Meinsh (cop[2]).

Plot 2. Pine forest of the type sedge-goutweed. Geographic coordinates: N 58.462483°, E 68.623517°. On the site, we observed four tree species: (1) *Betula pendula* Roth, (2) *Pinus sylvestris* L., (3) *Abies sibirica* Ledeb., and (4) *Tilia cordata* Mill (undergrowth). The grass cover is represented by the following:

- Stratum 1: *Aconitum septentrionale* Koelle, *Cacalia hastata* L.;
- Stratum 2: *Atragene sibirica* L., *Aegopodium podagraria* L., *Filipendula ulmaria* (L.) Maxim.;
- Stratum 3: *Rubus saxatilis* L., *Ranunculus acris* L., *Carex macroura* Meinsh., *Dactylis glomerata* L., *Lathyrus vernus* (L.) Bernh.;
- Stratum 4: *Glechoma hederacea* L., *Stellaria bungeana* Fenzl, *Ranunculus repens* L., *Plantago major* L., *Stellaria holostea* L., *Equisetum sylvaticum* L., *Viola mirabilis* L., *Vicia sepium* L., *Paris quadrifolia* L. dominated by *Carex macroura* Meinsh.(cop2), *Aegopodium podagraria* L. (cop[1]).

Plot 3. Meadows of goatweed-dropwort type. Geographic coordinates: N 58. 264 °, E 68.747083°. Grass plants are distributed in strata as follows:

- Stratum 1: *Angelica sylvestris* L.;
- Stratum 2: *Ranunculus polyanthemos* L., *Filipendula ulmaria* (L.) Maxim., *Veronica longifolia* L., *Pimpinella saxifraga* L. *Deschampsia cespitosa* (L.) P. Beauv.;
- Stratum 3: *Trollius europaeus* L., *Hypericum perforatum* L., *Lathyrus pratensis* L., *Phleum pratense* L., *Agrostis tenuis* Sibth., *Carex pallescens* L., *Vicia cracca* L., *Galium mollugo* L., *Trifolium medium* L. dominated by *Hypericum perforatum* L. (cop[1]), *Filipendula ulmaria* (L.) Maxim. (cop[2]).

Plot 4. Aspen forests of the goutweed type. Geographical coordinates: N 58.182667°, E 68.635133°. On the site, we observed four tree species: (1) *Populus tremula* L., (2) *Betula pendula* Roth, (3) *Picea obovata* Ledeb., (4) *Tilia cordata* Mill (undergrowth). The grass cover is represented by the following:

- Stratum 1: *Artemisia vulgaris* L., *Cirsium arvense* (L.) Scop., *Angelica sylvestris* L.;
- Stratum 2: *Thalictrum simplex* L., *Ranunculus polyanthemos* L., *Filipendula ulmaria* (L.) Maxim.;
- Stratum 3: *Vicia sepium* L., *Trifolium medium* L., *Aegopodium podagraria* L., *Hypericum perforatum* L., *Equisetum sylvaticum* L.;
- Stratum 4: *Carex macroura* Meinsh., *Alchemilla* sp. dominated by: *Aegopodium podagraria* L. (cop[1]), *Filipendula ulmaria* (L.) Maxim. (cop[2]).

Plot 5. Birch forests of the goutweed-sedge type. Geographical coordinates: N 58.070283°, E 69.043783°. On the site, we observed five species: (1) *Betula pendula* Roth, (2) *Pinus sylvestris* L., (3) *Populus tremula* L., (4) *Abies sibirica* Ledeb (undergrowth), (5) *Tilia cordata* Mill (undergrowth). Grass plants are distributed in strata as follows:

- Stratum 1: *Angelica sylvestris* L., *Vicia sylvatica* L.;
- Stratum 2: *Galium mollugo* L., *Trifolium medium* L., *Geranium sylvaticum* L., *Lathyrus vernus* (L.) Bernh., *Aegopodium podagraria* L.;
- Stratum 3: *Rubus saxatilis* L., *Carex macroura* Meinsh dominated by: *Aegopodium podagraria* L. (cop[1]), *Carex macroura* Meinsh. (cop[2]).

Plot 6. Meadows of the goatweed-clover type. Geographical coordinates: N 58.14095°, E 68.790083°. The grass cover is represented by:

- Stratum 1: *Dactylis glomerata* L., *Centaurea scabiosa* L., *Veronica longifolia* L., *Picris hieracioides* L., *Pimpinella saxifraga* L., *Centaurea integrifolia* Tausch;
- Stratum 2: *Agrostis tenuis* Sibth., *Bromopsis inermis* (Leyss.), *Origanum vulgare* L., *Rhinanthus aestivalis* (N.W. Zinger), *Vicia cracca* L., *Trifolium medium* L., *Galium mollugo* L., *Achillea millefolium* L., *Hypericum perforatum* L.;
- Stratum 3: *Plantago media* L., *Agrostis tenuis* Sibth., *Rumex acetosa* L. dominated by: *Hypericum perforatum* L. (cop[1]), *Trifolium medium* L. (cop[2]).

Plot 7. Fir forests of the shamrock-sedge type. Geographical coordinates: N 58.300533°, E 68.61505°. On the site, we observed two species: (1) *Abies sibirica* Ledeb., (2) *Betula pendula* Roth. Grass plants are distributed in strata as follows:

- Stratum 1: *Thalictrum minus* L., *Cacalia hastata* L.;
- Stratum 2: *Lathyrus vernus* (L.) Bernh., *Vicia sylvatica* L., *Geranium sylvaticum* L., *Atragene sibirica* L., *Aegopodium podagraria* L., *Dactylis glomerata* L.;
- Stratum 3: *Fragaria vesca* L., *Stellaria bungeana* Fenzl, *Stellaria holostea* L., *Equisetum sylvaticum* L., *Vicia sepium* L., *Paris quadrifolia* L.;
- Stratum 4: *Maianthemum bifolium* (L.) F.W, *Rubus saxatilis* L., *Viola mirabilis* L., *Oxalis acetosella* L., *Carex macroura* Meinsh dominated by *Oxalis acetosella* L. (cop[1]), *Carex macroura* Meinsh. (cop[2]).

Plot 8. Birch forests of the goatweed-sedge type. Geographical coordinates: Geographical coordinates: N 58.16375°, E 68.683°. On the site, we observed three species: (1) *Betula pendula* Roth, (2) *Populus tremula* L., (3) *Pinus sylvestris* L. (undergrowth). Grass plants are distributed in strata as follows:

- Stratum 1: *Solidago virgaurea* L., *Filipendula ulmaria* (L.) Maxim., *Centaurea phrigia* L.;
- Stratum 2: *Aegopodium podagraria* L., *Ranunculus polyanthemos* L.;
- Stratum 3: *Trifolium medium* L., *Pimpinella saxifraga* L., *Lathyrus pratensis* L., *Vicia sepium* L., *Hypericum perforatum* L.;
- Stratum 4: *Carex macroura* Meinsh dominated by: *Hypericum perforatum* L. (cop[1]), *Carex macroura* Meinsh (cop[2]).

Plot 9. Blueberry pine forests. Geographical coordinates: N 58.376717°, E 68.42055°. On the site, we observed three species: (1) *Pinus sylvestris* L., (2) *Betula pendula* Roth, (3) *Picea obovata* Ledeb. The grass cover is represented by:

- Stratum 1: *Solidago virgaurea* L., *Calamagrostis arundinacea* (L.) Roth.;
- Stratum 2: *Ledum palustre* L.;

- Stratum 3: *Trientalis europaea* L., *Rubus saxatilis* L., *Vaccinium myrtillus* L.;
- Stratum 4: *Linnaea borealis* L., *Maianthemum bifolium* (L.) F.W. Schmidt, *Carex macroura* Meinsh (sp) dominated by *Vaccinium myrtillus* L. (cop[1]), *Carex macroura* Meinsh (sp).

Plot 10. Shamrock pine forest. Geographical coordinates: N 58.266867°, E 68.263717°. On the site, we noted two species: (1) *Pinus sylvestris* L., (2) *Betula pendula* Roth (undergrowth). Grass plants are distributed in strata as follows:

- Stratum 1: *Thalictrum minus* L., *Calamagrostis arundinacea* (L.) Roth;
- Stratum 2: *Pimpinella saxifraga* L., *Agrostis tenuis* Sibth.;
- Stratum 3: *Galium mollugo* L., *Trifolium pretense* L., *Vicia cracca* L., *Phleum pratense* L.;
- Stratum 4: *Carex macroura* Meinsh., *Trifolium repens* L., *Plantago media* L., *Alchemilla* sp. dominated by: *Oxalis acetosella* L. (cop[1]), *Agrostis tenuis* Sibth. (sp).

Plot 11. Melilot-wheatgrass pastures. Geographical coordinates: N 58.180417°, E 68.684567°. The grass cover is represented by:

- Stratum 1: *Centaurea scabiosa* L., *Picris hieracioides* L., *Artemisia vulgaris* L., *Chamaenerion angustifolium* (L.) Scop., *Cichorium intybus* L., *Melilotus officinalis* (L.) Pall.;
- Stratum 2: *Phleum pratense* L., *Achillea millefolium* L., *Pimpinella saxifraga* L., *Hypericum perforatum* L., *Elytrigia repens* (L.) Nevski;
- Stratum 3: *Linaria vulgaris* Mill., Medicago × varia Martyn, *Berteroa incana* (L.) DC., *Rhinanthus aestivalis* (N.W. Zinger) Schischk. & Serg., *Vicia cracca* L. dominated by *Melilotus officinalis* (L.) Pall. (cop[1]), *Elytrigia repens* (L.) Nevski (cop[2]).

Plot 12. Oxtongue-pimpinella meadows. Geographical coordinates: N 58.077217°, E 68.791933°. Grass plants are distributed in strata as follows:

- Stratum 1: *Filipendula ulmaria* (L.) Maxim., *Thalictrum minus* L., *Picris hieracioide*s L., *Pimpinella saxifraga* L.;
- Stratum 2: *Knautia arvensis* (L.) J.M. Coult., *Hypericum perforatum* L.;
- Stratum 3: *Stellaria graminea* L., *Rhinanthus aestivalis* (N.W. Zinger), *Agrostis tenuis* Sibth., *Leucanthemum vulgare* Lam., *Galium mollugo* L., *Trifolium medium* L., *Achillea asiatica* Serg.;
- Stratum 4: *Alchemilla* sp. dominated by: *Picris hieracioides* L. (cop[1]), *Pimpinella saxifraga* L. (cop[2]).

Plot 13. Bentgrass-daisy meadows. Geographical coordinates: N 58.307133°, E 68.664267°. The grass cover is represented by:

- Stratum 1: *Centaurea phrigia* L.;
- Stratim 2: *Deschampsia cespitosa* (L.) P. Beauv., *Bromopsis inermis* (Leyss.);
- Stratum 3: *Equisetum sylvaticum* L., *Achillea millefolium* L., *Phleum pratense* L., *Trifolium hybridum* L., Trifolium medium L., *Hypericum perforatum* L., *Agrostis tenuis* Sibth., *Leucanthemum vulgare* Lam.;

- Stratum 4: *Chamaenerion angustifolium* (L.), *Prunella vulgaris* L., *Poa pratensis* L. dominated by: *Agrostis tenuis* Sibth. (cop1), *Leucanthemum vulgare* Lam. (cop2).

Plot 14. Goatweed-wheatgrass meadows. Geographical coordinates: N 58.318067°, E 68.524883°. Grass plants are distributed in strata as follows:

- Stratum 1: *Chamaenerion angustifolium* (L.), *Artemisia vulgaris* L., *Cirsium arvense* (L.);
- Stratum 2: *Filipendula ulmaria* (L.) Maxim., *Poa pratensis* L., *Stachys palustris* L., *Elytrigia repens* (L.) Nevski;
- Stratum 3: *Phleum pratense* L., *Trifolium medium* L., *Lathyrus pratensis* L., *Hypericum perforatum* L.;
- Stratum 4: *Prunella vulgaris* L. dominated by *Hypericum perforatum* L. (cop^1), *Elytrigia repens* (L.) Nevski (cop^2).

Plot 15. Birch forests of the sedge type. Geographical coordinates: N 58.5325°, E 68.692233°. On the site, we observed three species: (1) *Betula pendula* Roth, (2) *Abies sibirica* Ledeb., (3) *Picea obovata* Ledeb. The grass cover is represented by:

- Stratum 1: *Milium effusum* L., *Solidago virgaurea* L.;
- Stratum 2: *Equisetum sylvaticum* L., *Rubus saxatilis* L., *Trientalis europaea* L.;
- Stratum 3: *Gymnocarpium dryopteris* (L.) Newman, *Vicia sepium* L., *Melampyrum sylvaticum* L., *Lathyrus vernus* (L.) Bernh., *Aegopodium podagraria* L.;
- Stratum 4: *Oxalis acetosella* L., *Maianthemum bifolium* (L.) F.W. Schmidt, *Luzula pilosa* (L.) Willd., *Rubus saxatilis* L., *Fragaria vesca* L., *Paris quadrifolia* L., *Carex macroura* Meinsh. dominated by: *Carex macroura* Meinsh. (cop^1), *Aegopodium podagraria* L. (sp).

Plot 16. Birch forests of the short grass or oak fern type. Geographical coordinates: N 58.613017°, E 68.77035°. On the site, we observed three species: (1) *Betula pendula* Roth, (2) *Populus tremula* L., and (3) *Picea obovata* Ledeb. (undergrowth). Grass plants are distributed in strata as follows:

- Stratum 1: *Atragene sibirica* L., *Aegopodium podagraria* L.;
- Stratum 2: *Rubus saxatilis* L., *Trientalis europaea* L., *Gymnocarpium dryopteris* (L.) Newman;
- Stratum 3: *Oxalis acetosella* L., *Maianthemum bifolium* (L.) F.W. Schmidt, *Carex macroura* Meinsh dominated by *Gymnocarpium dryopteris* (L.) Newman (cop^1), *Carex macroura* Meinsh. (sp).

Plot 17. Birch forests of the sedge-shamrock type. Geographical coordinates: N 58.576417°, E 68.728783°. On the site, we observed four species: (1) *Betula pendula* Roth, (2) *Populus tremula* L., (3) *Picea obovata* Ledeb, and (4) *Tilia cordata* Mill (undergrowth). The grass cover is represented by:

- Stratum 1: *Dryopteris carthusiana* (Vill.) H.P. Fuchs, *Delphinium elatum* L.;
- Stratum 2: *Equisetum sylvaticum* L., *Aegopodium podagraria* L., *Trientalis europaea* L., *Poa trivialis* L.;

- Stratum 3: *Gymnocarpium dryopteris* (L.) Newman, *Paris quadrifolia* L., *Stellaria holostea* L., *Stellaria bungeana* Fenzl;
- Stratum 4: *Maianthemum bifolium* (L.) F.W. Schmidt, *Carex macroura* Meinsh., *Oxalis acetosella* L. dominated by *Carex macroura* Meinsh. (cop^1), *Oxalis acetosella* L. (cop^2).

Plot 18. Dandelion-vetch meadows. Geographical coordinates: N 58.192283°, E 68.507317°. Grass plants are distributed in strata as follows:

- Stratum 1: *Arctium lappa* L., *Centaurea phrigia* L., *Artemisia vulgaris* L., *Pimpinella saxifraga* L.;
- Stratum 2: *Galium mollugo* L., *Ranunculus acris* L., *Leucanthemum vulgare* Lam., *Vicia cracca* L., *Phleum pratense* L., *Achillea millefolium* L., *Dactylis glomerata* L., *Trifolium medium* L.;
- Stratum 3: *Plantago media* L., *Veronica chamaedrys* L., *Dianthus deltoides* L., *Vicia cracca* L., *Lathyrus pratensis* L., *Taraxacum* sp. dominated by: *Taraxacum* sp. (cop^1), *Vicia cracca* L. (cop^2).

Plot 19. Clover-daisy meadows. Geographical coordinates: N 58.174767°, E 68.632267°. Grass plants are distributed in strata as follows:

- Stratum 1: *Tanacetum vulgare* L., *Picris hieracioides* L.;
- Stratum 2: *Dactylis glomerata* L., *Pimpinella saxifraga* L., *Rhinanthus aestivalis* (N.W. Zinger), *Festuca pratensis* Huds., *Leucanthemum vulgare* Lam.;
- Stratum 3: *Chamaenerion angustifolium* (L.), *Achillea asiatica* Serg., *Vicia cracca* L., *Galium mollugo* L., *Hypericum perforatum* L., *Stellaria holostea* L., *Carex praecox* Schreb., *Elytrigia repens* (L.) Nevski, *Trifolium medium* L. dominated by *Trifolium medium* L. (cop^1), *Leucanthemum vulgare* Lam. (cop^2).

Plot 20. Birch forests of the dropwort-goutweed type. Geographical coordinates: N 58.081283°, E 69.0995°. On the site, we observed two species: *Betula pendula* Roth, *Populus tremula* L. Grass plants are distributed in strata as follows:

- Stratum 1: *Aconitum septentrionale* Koelle, *Cacalia hastata* L., *Phragmites australis* (Cav.) Trin. ex Steud., *Pleurospermum uralense* Hoffm., *Angelica sylvestris* L.;
- Stratum 2: *Aegopodium podagraria* L., *Lathyrus vernus* (L.) Bernh., *Vicia sepium* L., *Trifolium medium* L., *Geranium sylvaticum* L., *Thalictrum simplex* L., *Filipendula ulmaria* (L.) Maxim.;
- Stratum 3: *Rubus saxatilis* L., *Pulmonaria mollis* Wulfen ex Hornem., *Elytrigia repens* (L.) Nevski, *Aegopodium podagraria* L. dominated by *Filipendula ulmaria* (L.) Maxim. (cop^1), *Aegopodium podagraria* L. (cop^2).

Plot 21. Clover-daisy meadows. Geographical coordinates: N 58.08405°, E 69.29015°. Grass plants are distributed in strata as follows:

- Stratum 1: *Lysimachia vulgaris* L., *Chamaenerion angustifolium* (L.);
- Stratum 2: *Achillea asiatica* Serg., *Aegopodium podagraria* L., *Veronica longifolia* L., *Filipendula ulmaria* (L.) Maxim.;

- Stratum 3: *Trifolium medium* L., *Rhinanthus aestivalis* (N.W. Zinger), *Lathyrus pratensis* L., *Poa pratensis* L., *Agrostis tenuis* Sibth. dominated by: *Agrostis tenuis* Sibth. (cop[1]), *Filipendula ulmaria* (L.) Maxim. (cop[2]).

Plot 22. Daisy-fescue meadows. Geographical coordinates: N 58.3061°, E 68.47885°. Grass plants are distributed in strata as follows:

- Stratum 1: *Chamaenerion angustifolium* (L.), *Pimpinella saxifraga* L.;
- Stratum 2: *Achillea asiatica* Serg., *Tanacetum vulgare* L., *Elytrigia repens* (L.) Nevski, *Festuca pratensis* Huds.;
- Stratum 3: *Vicia cracca* L., *Galium mollugo* L., *Trifolium medium* L., *Hypericum perforatum* L., *Rhinanthus aestivalis* (N.W. Zinger), *Stellaria holostea* L., *Carex praecox* Schreb, *Leucanthemum vulgare* Lam. dominated by *Leucanthemum vulgare* Lam. (cop[1]), *Festuca pratensis* Huds. (cop[2]).

Plot 23. Horsetail-cyprus meadows. Geographical coordinates: N 58.0381°, E 69.336517°. The grass cover is represented by:

- Stratum 1: *Chamaenerion angustifolium* (L.);
- Stratum 2: *Achillea asiatica* Serg., *Filipendula ulmaria* (L.) Maxim., *Poa pratensis* L., *Equisetum hyemale* L.;
- Stratum 3: *Phleum pratense* L., *Trifolium medium* L.;
- Stratum 4: *Stellaria bungeana* Fenzl, *Rhinanthus aestivalis* (N.W. Zinger), dominated by *Equisetum hyemale* L. (cop[1]), *Chamaenerion angustifolium* (L.) (cop[2]).

Plot 24. Birch forests of the sedge-goutweed type. Geographical coordinates: N 58.166817°, E 68.44815°. On the site, we observed four species: (1) *Betula pendula* Roth, (2) *Pinus sylvestris* L., and (3) *Populus tremula* L., (4) *Tilia cordata* Mill. (undergrowth). Grass plants are distributed in strata as follows:

- Stratum 1: *Centaurea scabiosa* L., *Angelica sylvestris* L., *Calamagrostis arundinacea* (L.) Roth);
- Stratum 2: *Bromopsis inermis* (Leyss.) Holub, *Geranium sylvaticum* L., *Vicia sylvatica* L., *Aegopodium podagraria* L.;
- Stratum 3: *Galium mollugo* L., *Trifolium medium* L., *Lathyrus vernus* (L.) Bernh., *Hypericum perforatum* L.;
- Stratum 4: *Rubus saxatilis* L., *Carex macroura* Meinsh. dominated by: *Carex macroura* Meinsh. (cop1), *Aegopodium podagraria* L. (cop2).

Plot 25. Fir forests of the sedge-goutweed type. Geographical coordinates: N 58.470417°, E 68.671283°. On the site, we observed three species: (1) *Abies sibirica* Ledeb., (2) *Betula pendula* Roth, (3) *Tilia cordata* Mill (undergrowth). The grass cover is represented by:

- Stratum 1: *Angelica sylvestris* L., *Aconitum septentrionale* Koelle;
- Stratum 2: *Vicia sylvatica* L., *Thalictrum minus* L., *Dactylis glomerata* L.;
- Stratum 3: *Paris quadrifolia* L., *Lathyrus vernus* (L.) Bernh., *Rubus saxatilis* L., *Stellaria bungeana* Fenzl, *Equisetum sylvaticum* L., *Filipendula ulmaria* (L.) Maxim., *Carex praecox* Schreb., *Aegopodium podagraria* L.;

- Stratum 4. *Oxalis acetosella* L., *Trientalis europaea* L. dominated by *Carex praecox* Schreb. (cop[1]), *Aegopodium podagraria* L. (cop[2]).

Plot 26. Reedgrass and dropwort meadows. Geographical coordinates: N 58.124683°, E 68.422217°. Grass plants are distributed in strata as follows:

- Stratum 1: *Chamaenerion angustifolium* (L.), *Calamagrostis arundinacea* (L.) Roth;
- Stratum 2: *Lysimachia vulgaris* L., *Aegopodium podagraria* L., *Veronica longifolia* L., *Poa pratensis* L., *Filipendula ulmaria* (L.) Maxim.;
- Stratum 3: *Achillea asiatica* Serg., *Phleum pratense* L., *Trifolium medium* L., *Rhinanthus aestivalis* (N.W. Zinger), *Lathyrus pratensis* L., *Vicia sepium* L., *Hypericum perforatum* L. dominated by *Calamagrostis arundinacea* (L.) Roth (cop[1]), *Filipendula ulmaria* (L.) Maxim. (cop[2]).

Plot 27. Birch forests of the sedge-goutweed type. Geographical coordinates: N 58.412917°, E 68.44535°. On the site, we observed two species: (1) *Betula pendula* Roth, (2) *Populus tremula* L. Grass plants are distributed in strata as follows:

- Stratum 1: *Cacalia hastata* L.;
- Stratum 2: *Solidago virgaurea* L., *Lactuca sibirica* (L.) Benth. ex Maxim., *Impatiens noli-tangere* L., *Aegopodium podagraria* L.;
- Stratum 3: *Equisetum sylvaticum* L., *Bromopsis inermis* (Leyss.), *Vicia sylvatica* L., *Brachypodium pinnatum* (L.) Beauv., *Deschampsia cespitosa* (L.) P. Beauv.;
- Stratum 4: *Vicia sepium* L., *Scutellaria galericulata* L., *Ranunculus repens* L., *Carex praecox* Schreb. dominated by: *Carex praecox* Schreb. (cop[1]), *Aegopodium podagraria* L. (cop[2]).

As a result of the investigation, 111 species of vascular plants were found from 33 families in the composition of the plant communities. The following areas belong to meadow and forest vegetation: birch forests (33%); pine forests (10%); fir trees (8%); aspen forests (4%); meadow associations (45%).

This type of vegetation is characterized by a relatively low floristic saturation (9 to 29 species for an accounting area of 100 m^2). The study revealed the heterogeneity of the forming plant communities, including species that differ in ecological and coenotic characteristics. The maximum number of species was observed in plot 12 (29 species); the minimum number of species was observed in plot 23 (nine species).

To determine the degree of anthropogenic transformation of the flora and individual plant communities, we defined the synanthropization index (the ratio of synanthropic species to the total number of species). In the synanthropic fraction of the flora, we identified 45 species belonging to 12 families, with the most multispecies being: Apiaceae, Scrophulariaceae, Compositeae, Ranunculaceae, Poaceae, Fabaceae, Plantaginaceae. The synanthropization index of the studied phytocenoses ranges from 6.6% to 81.2% (Fig. 1).

The largest number of synanthropic species occurs in meadow associations, the content of synanthropes is greater than 50%, the structure is becoming more superficial, and the productivity and stability of plant communities are changing.

The maximum values of the synanthropization index (five points) according to the five-point system of R.I. Burda were recorded in plots 8, 10, 12, 13, 14, 18, 19, 21, 22, 23, 26 (the content of synanthropes at the site is over 50%). The synanthrope content at the sites not exceeding 50% was detected in plots 2, 24, 27 (4 points), max. 30% was in plots 5, 7, 15, 17, 20 (3 points) and less than 10% was in plots 9, 16, 25 (2 points).

Synanthropic vegetation is made up mainly of species of the local flora – apophytes (immigrants from various primary habitats).

The high values of the synanthropization index of vegetation cover indicate disturbance of the original plant communities, leading to a weakening of viability of the native flora species. Species of local flora make up the synanthropic vegetation of the studied areas.

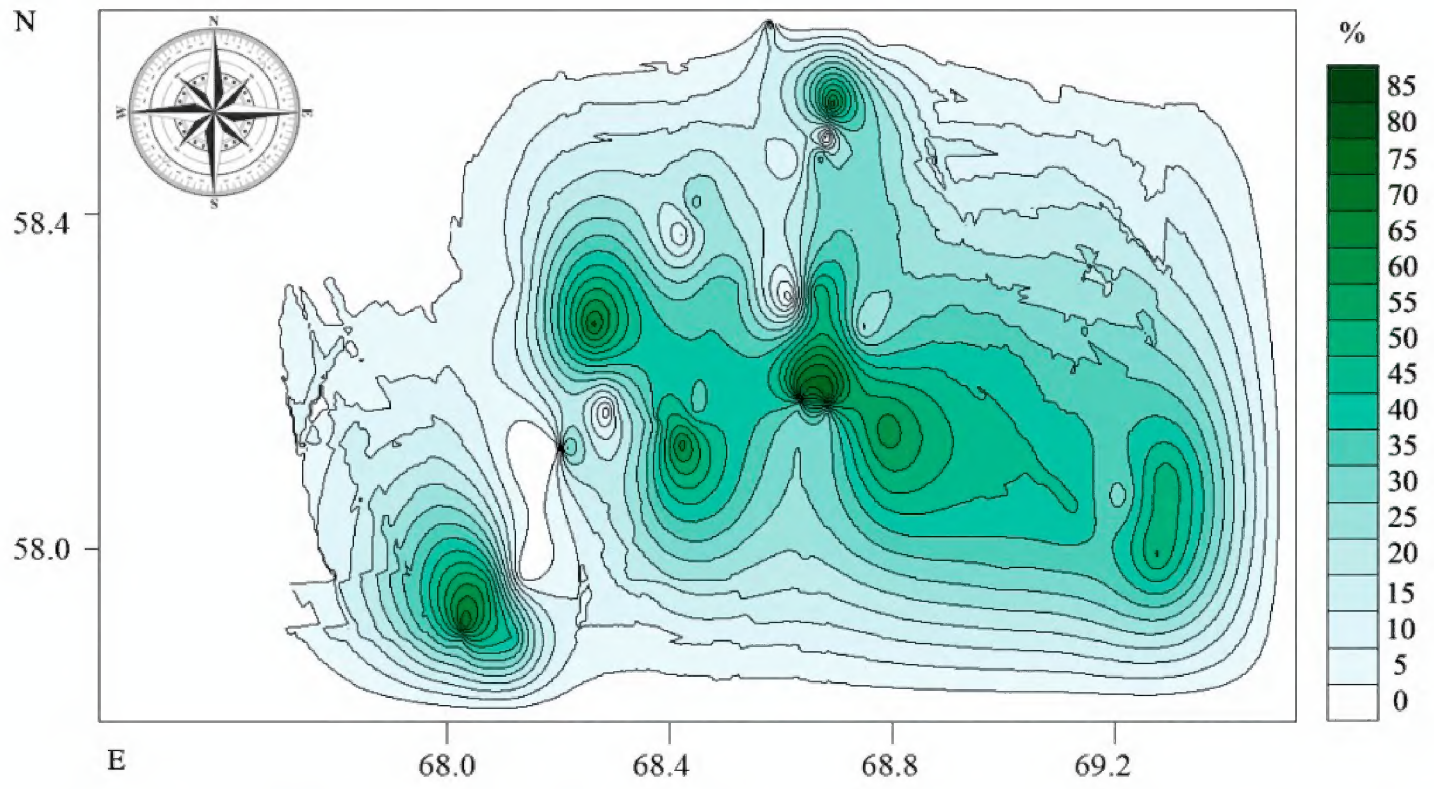

Figure 1. Percentage of synanthropization of the area under study. Source: Compiled by the authors.

Discussion

Many researchers note that high values of the vegetation cover synanthropization index indicate the disturbance of the original plant communities leading to weakening of the viability of the native flora species (Stohlgren et al. 2008; Hejdaet al. 2017). There is a simplification of the structure, a change in the productivity and stability of plant communities (Kadereit 1990; Guirado et al. 2006; Julian et al. 2012; Capon and Reid 2016; Moxham et al. 2019).

To limit the negative consequences of the processes of synanthropization of vegetation and to ensure the practical application of the results obtained, we can recommend several measures: (1) annual monitoring of plant communities to reveal

the dynamics of degradation; (2) identification and conservation of populations of rare endangered plant species; (3) restoration of plant communities through environmental restoration (Pellissier et al. 2013; Oduor et al. 2016; Chen et al. 2017).

The research results indicate that the anthropogenic impact on the flora of the studied areas manifests itself in two opposite directions: a decrease in the number of local species (the indigenous component of the flora) and an increase in the fraction of anthropogenic flora.

Conclusion

As a result of the studies conducted in 27 research plots, we revealed the flora of anthropogenically transformed habitats of floodplain ecosystems in the Ob-Irtysh basin and evaluated the degree of synanthropization of plant communities. We also found that 111 species of vascular plants were found in the composition of plant communities from 33 families. In the synanthropic fraction of the flora, we determined 45 species belonging to 12 families, with the most multispecies being: Apiaceae, Scrophulariaceae, Compositeae, Ranunculaceae, Poaceae, Fabaceae, Plantaginaceae. The synanthropization index of the studied phytocenoses ranges from 6.6% to 81.2%. Synanthropic vegetation is made up mainly of local flora species, apophytes (immigrants from various primary habitats).

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